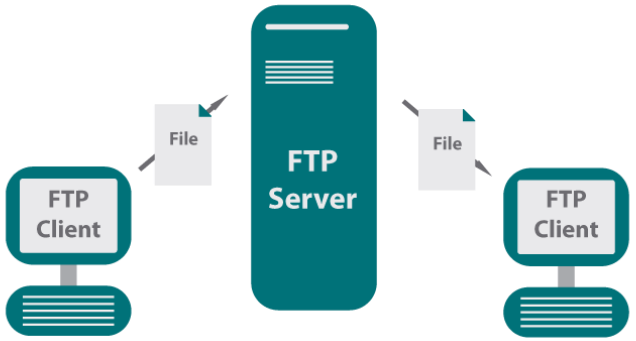
FTP

Computer Network
Project 1

What is FTP?

- Application layer protocols: SSH, P2P, FTP, etc.
- A protocol used for file download or upload between server and client.

SSH

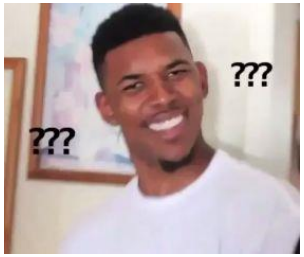


P2P

How to implement an FTP?

1. Open computer;
2. Write code;
3. Run code;

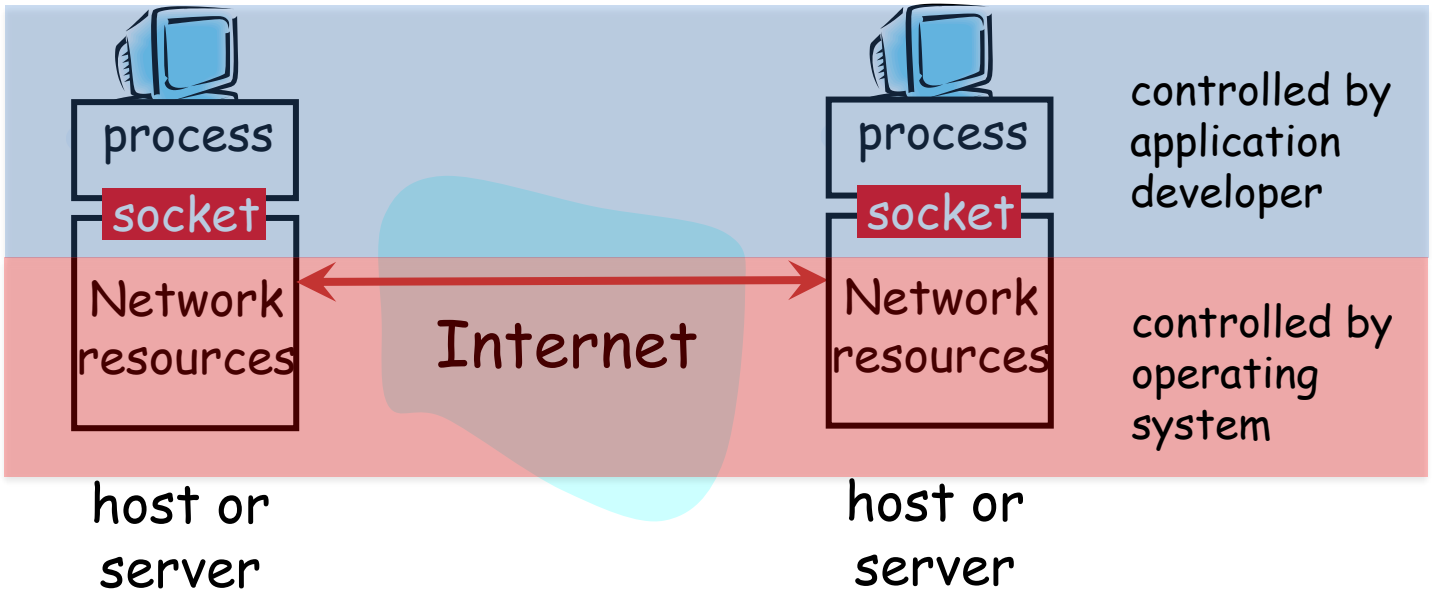
Is that so?



Socket Programming

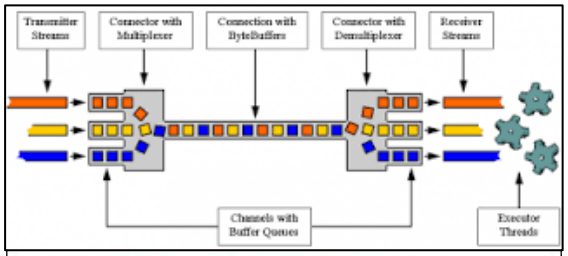
What is Socket?

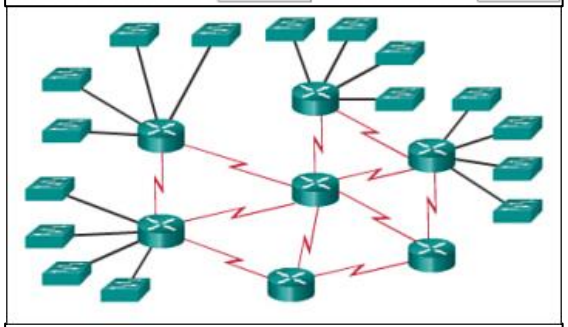
- Socket is an API to use internet resources.
- Host-local, application-created, OS-controlled interface.

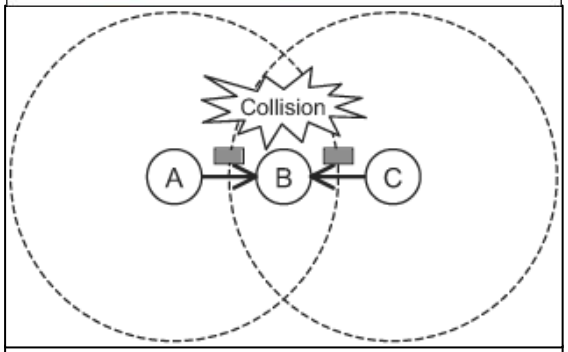


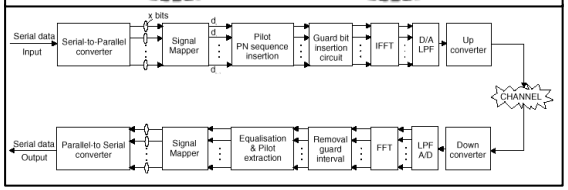
Why do we need socket?

- Layering



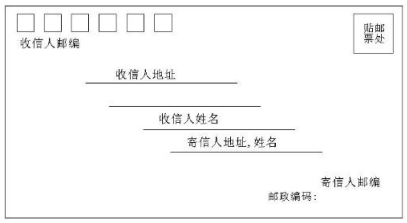






Socket Identification

Mail	Call	Socket
Your Address	Your Phone Num.	Local Socket Address
Her Address	Her Phone Num.	Remote Socket Address
Envelop	Radio	Protocol



Socket?

Address

- The address must identify the sender/receiver.
  - Identification of the host – IP Address
    - IPv4: 32bit, X.X.X.X, X:8 bit
    - IPv6: 128bit, Y:Y:Y:Y:Y:Y:Y:Y, Y:16 bit
  - Identification of the process – Port
    - 0~65535
- The five tuples to specify a socket:
  - (SrcIP, SrcPort, DstIP, DstPort, Protocol)

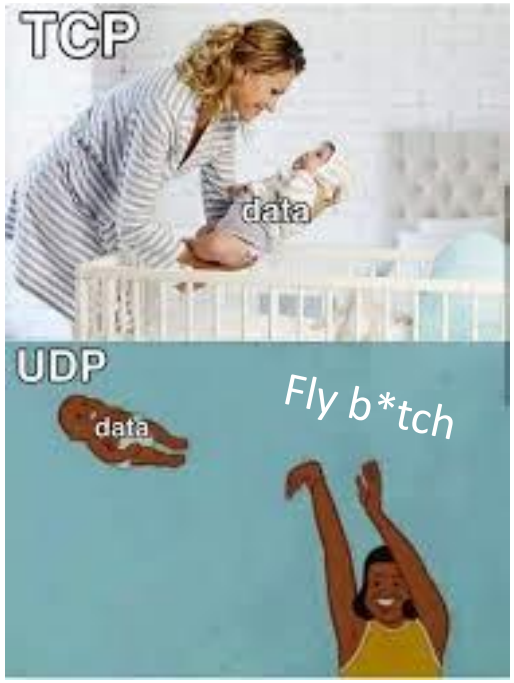
Port Usage

- Popular applications have "well-known ports".
  - By convention, between 0 and 1023; privileged
  - E.g., port 80 for HTTP, 25/465 for SMTP, 21 for FTP
  - For more, refer to Wikipedia.
- Custom client gets an unused "ephemeral" port.
  - By convention, between 1024 and 65535.

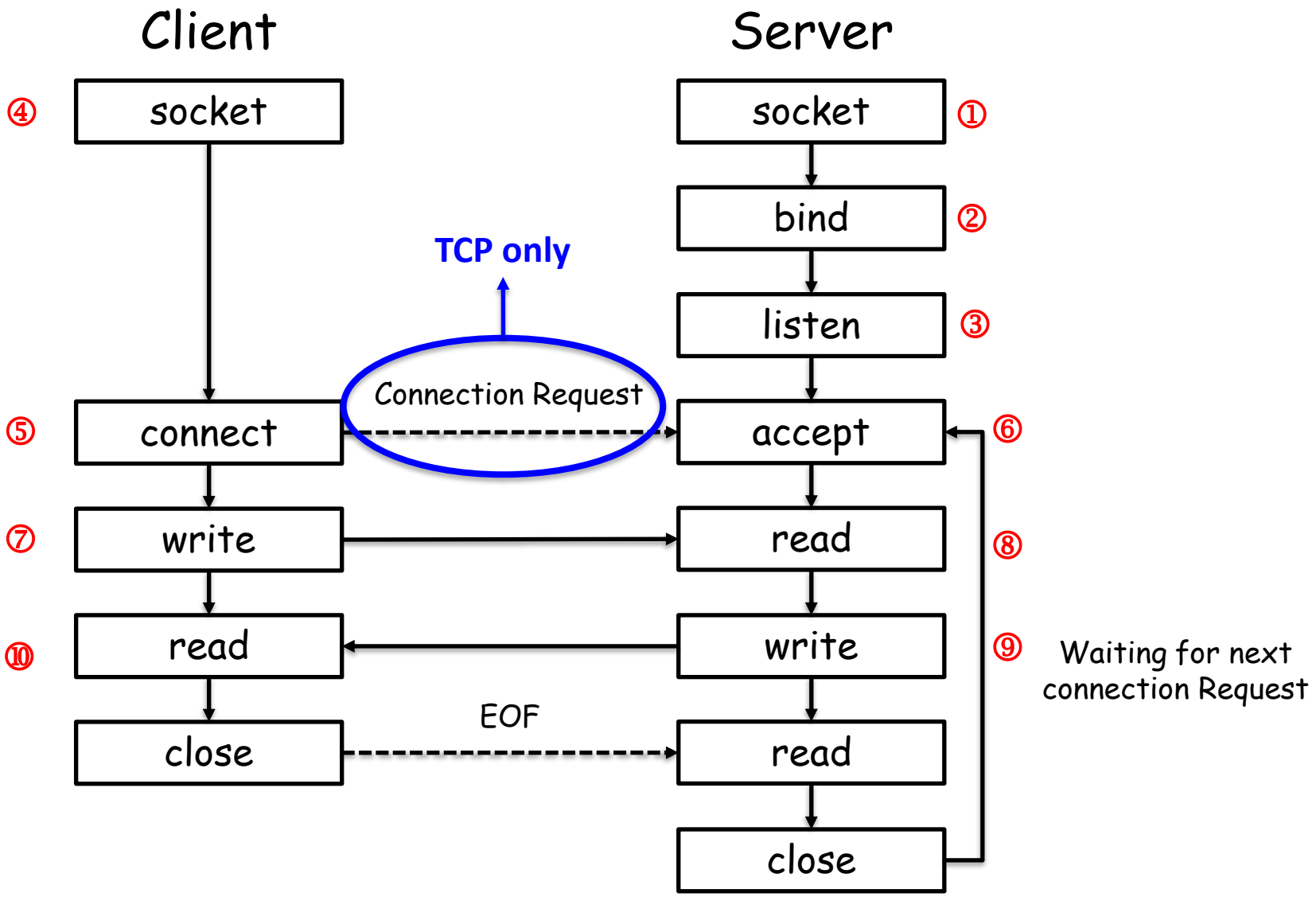
```
[root@esonjohn ~]# netstat -tunlp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address               Foreign Address             State       PID/Program name
tcp        0      0 0.0.0.0:21                  0.0.0.0:*                   LISTEN      790/vsftpd
tcp        0      0 0.0.0.0:25                  0.0.0.0:*                   LISTEN      807/exim
tcp        0      0 0.0.0.0:1723                0.0.0.0:*                   LISTEN      847/pptpd
tcp        0      0 0.0.0.0:587                 0.0.0.0:*                   LISTEN      807/exim
tcp        0      0 0.0.0.0:80                  0.0.0.0:*                   LISTEN      835/nginx
tcp        0      0 0.0.0.0:465                 0.0.0.0:*                   LISTEN      807/exim
tcp        0      0 0.0.0.0:28883               0.0.0.0:*                   LISTEN      776/sshd
```

Transport Layer Protocol

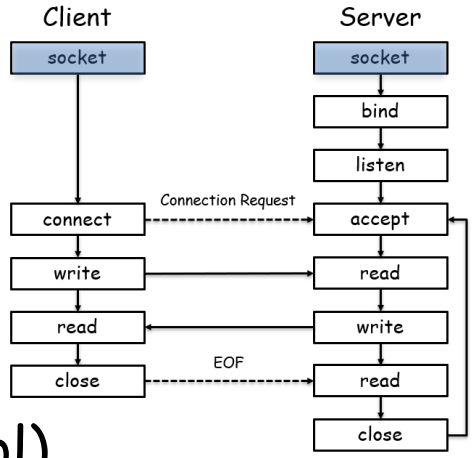
- Socket at Transport Layer.
  - TCP
    - Connection-oriented protocol
    - Reliable, ordered, heavyweight and streaming
  - UDP
    - Connectionless protocol
    - Unreliable, not ordered, lightweight and datagrams



Socket Programming in C

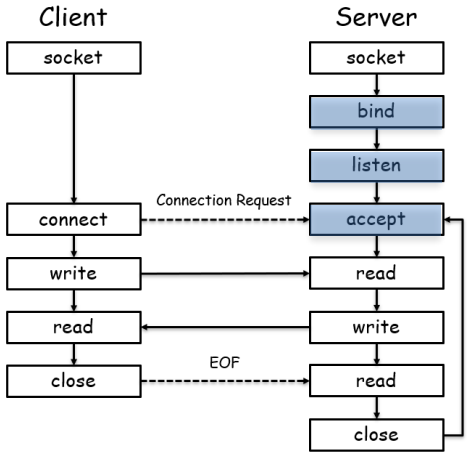


API Functions



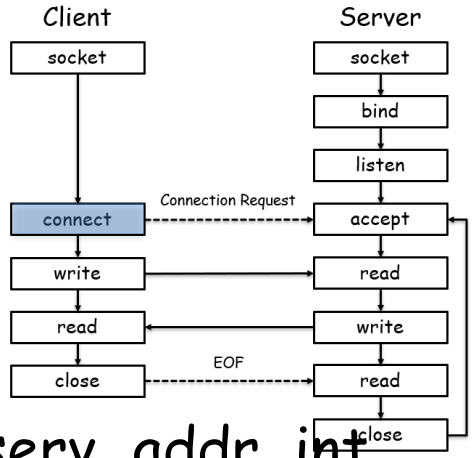
- Create a socket
  - int socket(int domain, int type, int protocol)
    - Domain: ipv4/ipv6
    - Type: SOCK_STREAM/SOCK_SEQPACKET/…
    - Protocol: TCP/UDP/…

API Functions



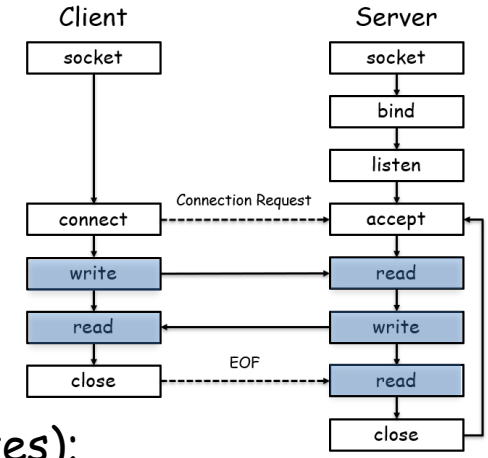
- Server listening
  - Bind some port
    - int bind (int sockfd, struct sockaddr *my_addr, int addrlen)
      - sockfd: socket handler
      - my_addr: local listening address
      - addrlen: my_addr length
  - Define how many connections can be pending
    - int listen(int sockfd, int backlog)
      - sockfd: socket handler
      - backlog: maximum connections
  - Accept a new connection from a client
    - int accept(int sockfd, struct sockaddr *addr, int *addrlen)
      - sockfd: socket handler
      - addr: client address
      - addrlen: addr length

API Functions



- Establish a connection
  - int connect(int sockfd, struct sockaddr *serv_addr, int addrlen)
    - sockfd: socket handler
    - serv_addr: server address
    - addrlen: serv_addr length

API Functions



- For TCP, Send Data
  - ssize_t write(int sockfd, const void *buf, size_t nbytes);
  - ssize_t send(int sockfd, const void *buf, size_t nbytes, int flags);
    - sockfd: socket handler
    - buf: data buffer
    - nbytes: write/send data length
    - flags: block/nonblock/…
- For TCP, Receive Data
  - ssize_t read(int sockfd, void *buff, size_t nbytes);
  - ssize_t recv(int sockfd, void *buff, size_t nbytes, int flags);
- For UDP, use
  - ssize_t sendto (int sockfd, void *buff, size_t nbytes, int flags, const struct sockaddr *dest_addr, int addrlen);
  - ssize_t recvfrom (int sockfd, void *buff, size_t nbytes, int flags, const struct sockaddr *src_addr, int addrlen);

API Functions

- Byte Ordering
  - unsigned long int htonl(unsigned long int hostlong)
  - unsigned short int htons(unsigned short int hostshort)
  - unsigned long int ntohl(unsigned long int netlong)
  - unsigned short int ntohs(unsigned short int netshort)
- IP Addresses
  - int inet_aton(const char *cp, struct in_addr *inp)
  - char *inet_ntoa(struct in_addr in);

Other Tools

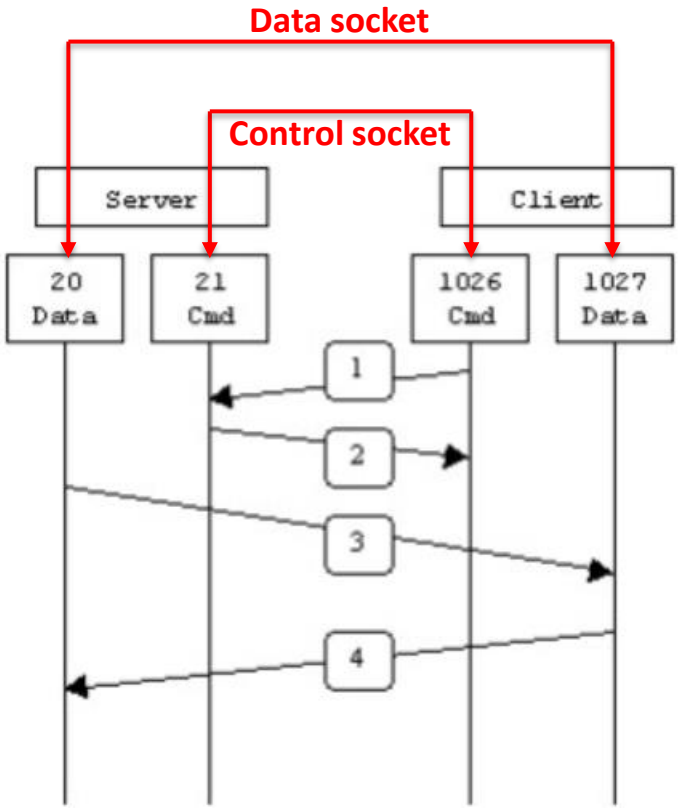
- How to check if particular port is listening
  - Windows – use netstat
    - netstat -an
  - Linux – use nmap
    - nmap -sT -O localhost
- Status code of bind function indicates port usage
- Not knowing what exactly gets transmitted on the wire
  - Use tcpdump or Ethereal (www.ethereal.com)
- Check RFC if in doubt about protocols.
  - RFC 959

Commands in FTP

- USER, PASS
  - login to server
- RETR
  - download file from server
- STOR
  - upload file to server
- PORT, PASV
  - specify active/passive mode
- MKD, CWD, PWD, LIST
  - manipulate directories on server
- ...(rfc 959)

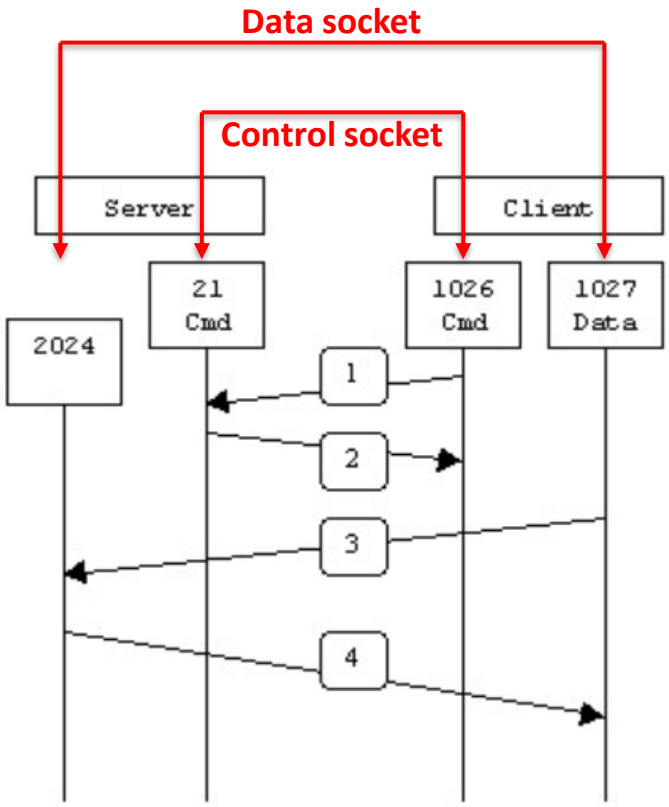
PORT Mode of FTP

- PORT(Active Model)
  - Server monitor default control port 21
  - Client request control port N1 (1026) from OS
  - Client request data port N2 (1027) from OS and notify Server
  - Server setup connection between local 20 port and client N2 (1027) port
  - Data streams between server 20 port and client N2 (1027) port

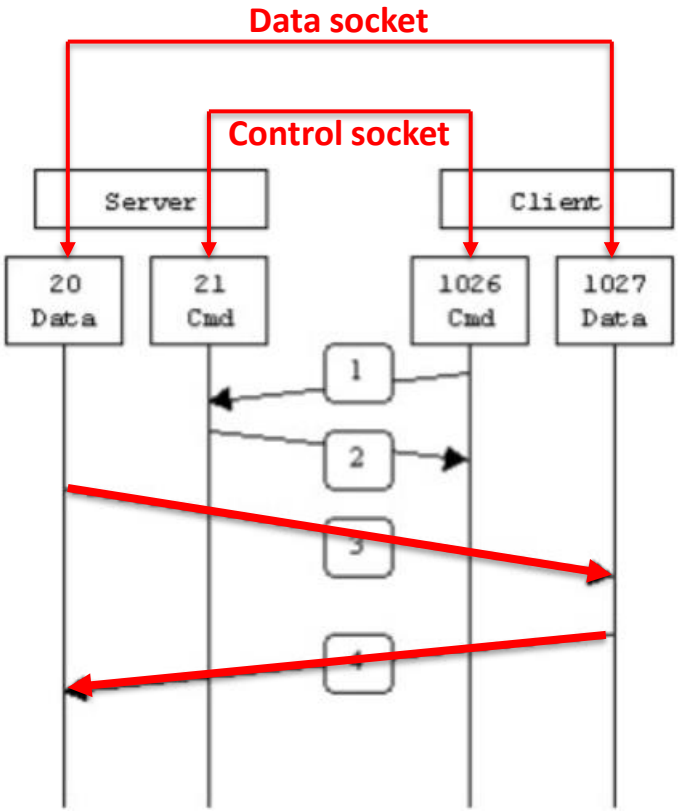


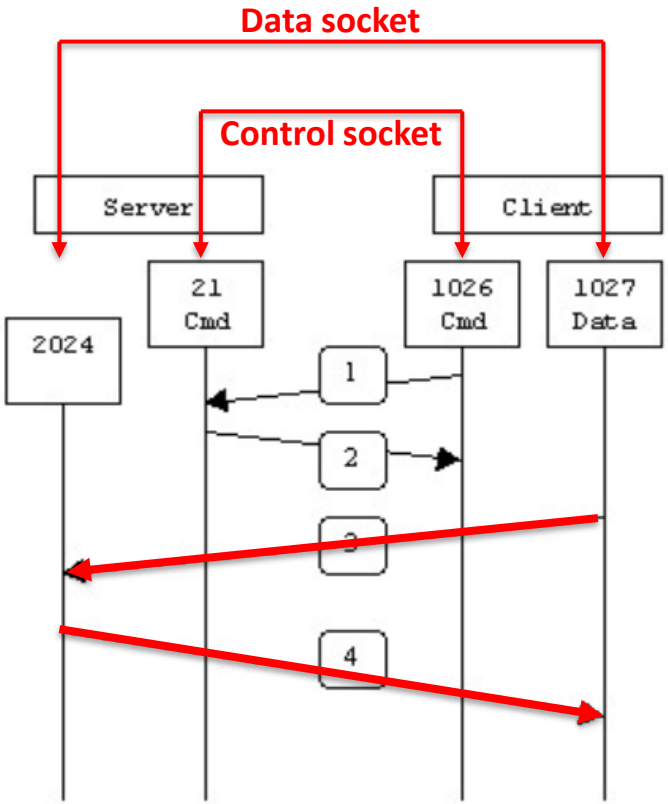
PASV Mode of FTP

- PASV(Passive Model)
  - Server monitor default control port 21
  - Client request control port N1 (1026) from OS
  - Client request data connection from Server on N1 (1026)
  - Server request data port N2 (2024) from OS and notify Client
  - Client request data port N3 from OS
  - Client setup connection between local port N3 and server port N2
  - Data streams between server port N2 and client port N3



PORT vs. PASV


Data socket
Control socket
Server
Client
20
Data
21
Cmd
1026
Cmd
1027
Data
1
2
3
4


Data socket
Control socket
Server
Client
2024
21
Cmd
1026
Cmd
1027
Data
1
2
3
4

Project Description

- Goal
  - Learn to setup communications between PCs with socket.
  - To be familiar with FTP protocol;
  - To be familiar with network protocol stack;
  - Learn to build client/server applications that communicate using sockets.

Task1: UDP Programming

- Read the sample code
  - Choose any language you are familiar with(C, C#, Java, node, Python).
- Modify the UDP Server and Client According to the homework guide.
- Questions:
  - How to write a chat programming (two clients chat with each other) with UDP?

Task2: Implementing FTP Server

- Must use the Berkeley Socket API (**Linux**) and write your server in C;
- Must serve files from a **designated directory** on your system to clients making requests on a designated TCP port;
- Must handle USER, PASS, RETR, STOR, QUIT, SYST, TYPE, PORT, PASV, MKD, CWD, PWD, LIST, RMD, RNFR, RNTO commands;
- Handling **invalid input** reasonably and generating defensible error codes;

Task2: Implementing FTP Server

- May not use any libraries containing code specifically designed to implement FTP functionality (coding at socket level);
- Support integral **large file** transmission;
- Support connections from **multiple** clients;
- **Optional**
  - (5%) **Resume** transmission after connection terminated;
  - (5%) File transmission **without blocking** the server;

Task3: Implementing FTP Client

- You can write your client in your **favorite** programming language;
- Must handle USER, PASS, RETR, STOR, QUIT, SYST, TYPE, PORT, PASV, MKD, CWD, PWD, LIST, RMD, RNFR, RNTO commands;
- Able to log in a provided **commercial** FTP server and download/upload files;
- Support integral **large file** transmission;

Task3: Implementing FTP Client

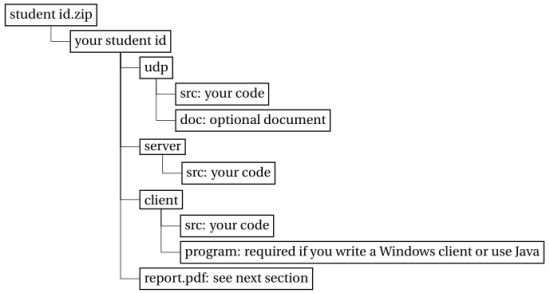
- May not use any libraries containing code specifically designed to implement FTP functionality (coding at socket level);
- **Optional**
  - (5%) **Resume** transmission after connection terminated;
  - (5%) Friendly GUI;
  - (5%) File transmission **without blocking** the GUI;

Some Important Issues

- Grading
  - UDP Programming (10%)
  - Implementation of FTP (70%+10%)
    - Server (40%)
    - Client (30%)
    - Optional (5%+5%)
  - Project Report (20%)
- Individual work.

Some Important Issues

- Submission
  - Source code for udp, server/client;
  - Executable file and how to run it;
  - Report: no longer than THREE pages.
  - Files are to be organized as follows:



- Evaluation
  - Auto-grading program for FTP server.
  - Face-to-face check for FTP client.

Some Important Issues

- Important Date
  - Start up: today (2023.9.27.)
  - **Due date**: 3.5 weeks later (**2023.10.22.**)

- Cheating will be punished.
  - Repetition rate > 20%
  - 0 score in the project

补交规则

- 正常提交: **在 DDL 前**提交作业正常计分
- 最迟提交期限和惩罚
  - 每次作业最迟在 DDL 后**一周（7天）内**提交，超出此期限**一律拒收**
  - 未超出此拒收期限的迟交作业得分***0.8**.
- 宽限期: 全部大作业共享 **7 天**宽限期。迟交**累计不超过**该期限的免于扣分惩罚

补交规则

- **例子**
  - 第一次大作业按时提交，第二次大作业未在最迟补交期限前（DDL后7天）提交 → 第一次大作业正常计分，第二次大作业不予补交
  - 第一次大作业迟交3天，第二次大作业迟交4天 → 累计迟交7天，未超过宽限期，两次大作业均正常计分
  - 第一次大作业迟交7天，第二次大作业迟交1天 → 第一次大作业正常计分；第二次大作业累计超过宽限期，仅得80%
  - 第一次大作业迟交7天，第二次大作业按时提交 → 第一次大作业累计超过宽限期，仅得80%；第二次大作业正常计分

Problems Emerged

- Improper use of control/data socket(list, pwd)
- Illegal design of command (PORT/PASV)
- Fails to connect to standard FTP server
  - Follow RFC protocol
- Security Issue
  - cd ..
- String Issue (\0)
- Exceptions
  - Socket exception
  - I/O exception

How to implement an FTP?

1. Read RFC959 document;
2. Coding ON YOUR OWN;
3. Debugging;

Previous Outstanding Project

Student A

1. 实验环境搭建
   - FTP server: Ubuntu20.04(WSL) + C(GNU C11) + CLion
   - FTP Client: Windows10 & macOS + C++11&Qt 5.12 + Qt Creator
2. FTP server

   2.1 实现的命令与对应的错误处理

命令与参数	功能说明	错误处理
USER <username>	只接受"anonymous"这一个用户名。永远发送给用户 331 请求填写密码。	收到错误用户名在服务器内部改变状态为 WRONGUSER，在 PASS 命令中处理
PASS <password>	用户填写邮箱为密码。正常时发送 230。	若用户名填写错误，发送 530 表示拒绝。若该请求不是紧接在 USER 后发送的，发送 503 表示拒绝。
SYST	告知客户端系统信息。正常时发送 215。	若请求中带有别的参数，以 500 告知客户端格式错误。
TYPE <type>	仅接受"Type I",正常时发送 200。	以 504 应对请求非 TYPE I。表示该参数不能处理。
PORT<h1,h2,h3,h4,p1,p2>	建立一个 socket 准备用于连接（不立即连接）。正常情况发送 200。	未登录以 530 回复；不能解析 IP 地址的情况以 501 回复；以 425 应对创建 socket 失败的情况。
PASV	在一个随机端口开启监听并告知客户端，等待客户端连接。正常情况发送 227 并告知客户端要连接的 IP 和端口。	以 530 回复未登录；以 425 应对创建 socket 失败或客户端没有连接上的情况。
RETR <filename> STOR <filename>	根据两种连接模式确认好连接后进行文件的传输。确认连接后发送 150 告知客户端传输开始。开启新的线程进行文件传输，传输成功以 226 告知客户端。	如果并不是两种连接状态之一，直接发送 425 表示没有建立连接。在文件传输进程里因管道破坏失败则发送 426。打不开文件发送 451。
QUIT	关闭所有该用户连接，发送 221	
LIST [path]	在主机上使用 ls -l 命令列出对应文件夹或文件的信息并发送给客户端。	如果给定的路径试图访问根目录的父目录，或者找不到该路径，发送 550。连接错误的处理方式同 RETR
MKD <path>	创建文件夹。	如果给定的路径试图访问根目录的父目录发送 550。
PWD	告知客户端当前工作目录。	
CWD <path>	把工作目录切换为指定目录。	如果给定的路径试图访问根目录的父目录或者找不到该路径，发送 550。
RNFR <filename>	准备重命名指定文件。回复 350	文件不存在则发 450，文件在根目录外发 550。
RNTO <filename>	重命名为指定文件名。回复 250 告知客户端重命名成功。	没有事先发 RNFR 则以 503 回复，文件在根目录外回复 550，重命名失败回复 553。

   2.2 实现方式

   将所有功能分为几个模块，实现在了对应名字的文件中。utils 模块中定义了核心的结构体 User 和枚举类型的 UserState。User 中包含了每个连接进来的用户的基本信息，具体参见 utils.h 中的注释。还包含了其他模块中要用到的一些工具函数，如解析 IP 地址。

   IO 模块中实现了与客户端数据的传输，包括了四个函数，分别对应发送消息、接收消息、发送文件、接收文件。

   command 模块中对所有的命令处理方式进行了实现，该模块中的所有函数都有着统一的函数签名。

   core 模块中是服务器开启的核心逻辑，包括初始化服务器，每个连接的处理过程，和根据用户请求调用不同命令的函数。

   server.c 中只有调用初始化服务器的 main 函数。

   服务器在 init_server 函数中完成一系列初始化后会持续监听连接请求，在连接数没有达到最大时接受请求并为每个连接开启新的线程，在这个线程中执行 main_process 函数来处理客户端的请求。有一个 while 循环不断地处理请求和接收请求。

   消息发送、消息接收函数以及所有实现命令的函数都有统一的返回风格，以返回 0 作为操作成功的标志，返回非 0 数表示运行错误。大部分命令都会需要给用户发出回复，直接采用 return send_message()的方式进行，如果发送消息成功了则会返回 0 表示命令运行成功，所发送失败则说明客户端已经主动断开连接，此时返回一个非 0 数，main_process 中的循环会终止，该用户被释放，对应线程也会结束。

   文件的传输都会开启新的线程，不会影响接收客户端请求。若收到退出的请求会关闭传输中的文件描述符并结束线程。

   用户的结构体中储存用户在服务器上的工作目录，而服务器的根目录用全局变量 rootDir 存储，在初始化时从参数中读取根目录，默认为/tmp。

3. FTP client

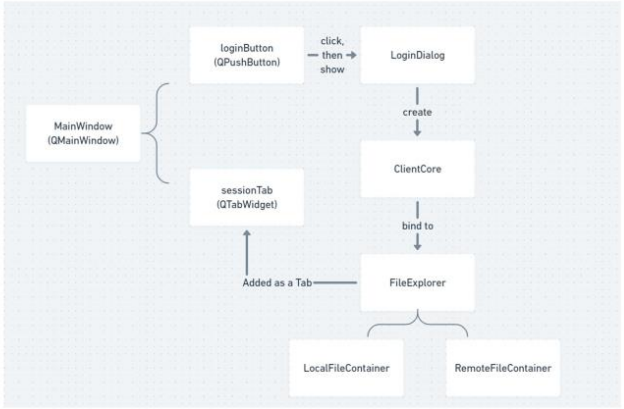
   3.1 功能实现与模块划分

   客户端核心的功能实现在类 ClientCore 中，该类继承 QObject，有发出各个命令的函数与处理服务器回复、实现文件传输功能的函数。每次完成一项命令操作都会发出信号。

   展示文件的类为 FileExplorer,该类绑定一个 ClientCore，调用 ClientCore 的函数进行对服务器的请求，根据 ClientCore 的信号展示相关信息给用户。该类的界面包含有显示本地文件和远端文件的区域，分别为 LocalFileContainer 和 RemoteFileContainer。

   LocalFileContainer 和 RemoteFileContainer 继承自 FileContainer,FileContainer 继承自 QListWidget，该类可以方便地以列表形式展示文件，继承该类并重写一些函数是为了实现文件拖拽上传的操作。

   主窗口为 MainWindow 类，窗口包含一个 QTabWidget 来存放多个会话对应的文件浏览器，左上角的 New Session 按钮点击后会弹出登录框，输入 IP 地址、端口、用户名与密码后就能进行登录。整体结构大致如下图：



   3.2 交互逻辑

   提供了与常见的图形界面文件系统相似的操作方式：

   1. 拖拽文件进行上传或下载
   2. 点击路径栏直接进行路径切换，或双击路径栏输入路径进行切换
   3. 双击进入文件夹；右键点击弹出操作菜单。
   4. 鼠标放在远程文件上时用 ToolTip 显示更完整的文件信息。

   在主要界面的左侧显示服务器的返回信息，下方显示提示。并提供了刷新远程文件夹和重新连接的按钮(重新连接按钮只有在检测到连接已断开时会启用)。

   在进行文件传输时也可以在各个会话之间切换，并对本地文件夹进行操作。但是不要对远程文件进行操作，因为每次操作都后都会发送 LIST 请求刷新文件夹，这可能会导致文件传输中断。

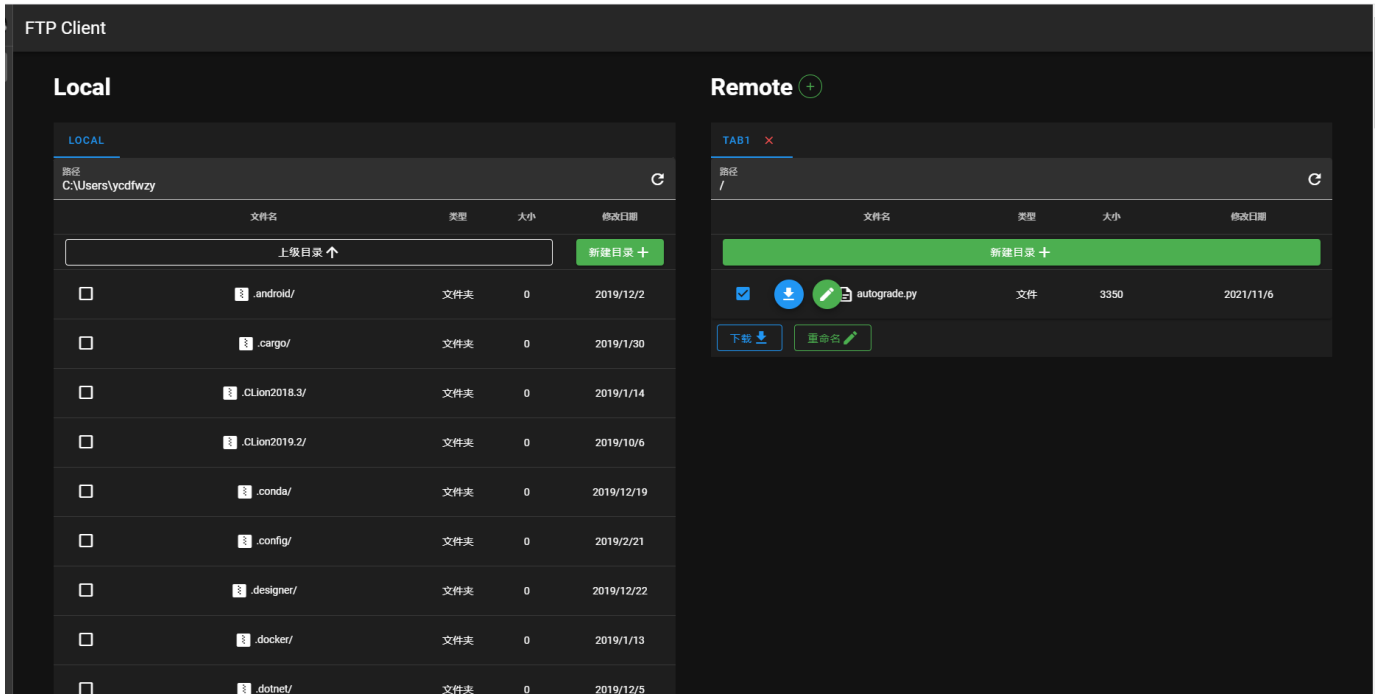
4. 实验感想

   这次从零开始根据协议实现 FTP server 是一个非常大的挑战，从最开始的无从下手到中间的各种 Bug 都几度让人心态炸裂。比较好的是从布置开始就一点一点写，战线拉得很长，才能在 DDL 前一天就写完了功能改好了致命的 Bug。

   编写 Client 的时候设想了很多很好的功能，但是在实现的中途因为各种函数设计的不合理导致了严重的 bug，改着改着时间就不够了，不得不放弃了一些原有的想法，最后只实现了很简陋的客户端，十分遗憾。

Previous Outstanding Project

Student B



Previous Outstanding Project

Student C

- **Handle the following exceptions:**
  - Catch password format exception;
  - Catch PORT data socket creating exception;
  - Catch PASV listening exception;
  - Catch RETR STOR I/O exception;
  - Catch thread creating exception;
  - Catch directory management exception;
  - Catch file management exception;
  - Catch illegal file path exception;
  - Catch control socket exception;
  - Catch data socket exception;

Happy National Day

Good luck